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UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

# THE FIR ENGRAVER BEETLE

# AND OTHER INSECTS IN WHITE FIR

by

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# THE FIR ENGRAVER BEETLE AND OTHER INSECTS IN WHITE FIR

## Introduction

The number of dead, dying and top-killed white fir trees has increased noticeably within recent years throughout the range of this species in California. Overmature stands of white fir give abundant evidence that this condition, perhaps in a less severe form, has existed for many years, as shown by the prevalence of top-killed trees and the scars of injury by insects imbedded in the wood of living trees and snags (Plate I). About 1924-25 an unusually large number of dying trees developed in young pole stands. This trouble has continued to increase, the season of 1929 being one in which very heavy losses occurred.

Several factors are responsible for this condition, chief among which are insects and fungi. Studies by the Bureau of Entomology have fixed the primary responsibility for the insect damage on the fir engraver beetle, Scolytus ventralis Lec., and the Sierra fir borer, Tetropium abietis Fall. Of these two insects the fir engraver beetle was found to be by far the most important, by reason of its primary attacks in practically all affected trees, whether top-killed or entirely killed. Attacks of the Sierra fir borer were confined largely to the lower, thicker, bark portion of the trunk in trees already attacked in the upper portion by the fir engraver beetle.

This paper is a brief presentation of the results of insect investigation in white fir during 1929 and 1930. These studies have been set forth in detail through reports of the Bureau of Entomology in 1929 and 1930.

## Character of Damage

Extent. While it is extremely difficult to obtain definite figures on losses, due to variability in the way white fir are attacked, surveys made in the vicinity of Strawberry showed that approximately 7 per cent of the volume and 4.5 per cent of the trees on cut-over areas were killed during 1928, 1929 and 1930. Young, vigorous-growing trees from pole size to over 30 inches in diameter were killed, often in groups, with a preference shown for the slower-growing trees of these stands. In virgin stands trees entirely killed amounted to approximately 2.5 per cent of the total volume of white fir in two representative areas surveyed. Top-killed trees were common in all stands, with approximately 3 per cent of trees on cut-over areas and 17 per cent on virgin stands affected.

Classification of Injured Trees. Because of the variation in the way trees are attacked, it was necessary to establish some convenient system of classification according to injury, in order to arrive at a satisfactory method of estimating loss. As a rule the injured trees can be grouped into the types represented in the following table:

Table I

| Description | Type I | Type II A | Type II B | Type III | Type IV |
|---|---|---|---|---|---|
| Amount of tree killed | Top only | Entire tree killed by one season of attack in young 2nd growth stand | Entire tree killed by one season of attack in old, mature stands | Entire tree killed by successive attacks occurring over a period of years, usually in mature stands | Patches killed on main trunk, often healing, but weakening vigor of tree |
| Frequency | Common | Result of beetle epidomics in second-grwth stands of pole-size trees and larger | Frequent in mature virgin stands | Common in all white fir stands | In all white fir stands |
| Insects responsible for initial killing | Fir engraver beetle | Fir engraver beetle | Fir engraver beetle and Sierra fir borer | Fir engraver beetle and Sierra fir borer | Fir engraver beetle |

## The Fir Engraver Beetle

### Recognition of Beetle Attack.

Freshly-attacked green trees are very difficult to locate in the field because there are no conspicuous pitch tubes and very few borings. Trees with a heavy attack often emit a considerable flow of balsam shortly after the beetles have entered the bark. Very frequently the attacks are confined to the upper part of the trunk, and no damage is suspected until the tree has begun to fade.

The work of the fir engraver beetle is recognized by widely-scattered small round holes on the trunk, especially where the bark is thin. The holes are inconspicuous where attacks are made on thick bark. The attacks penetrate to the cambium, where horizontal egg galleries are bored, which when complete average about 5 inches in length. By removing the bark of recently-attacked trees the egg galleries are exposed, as shown in Fig. 1, Plate II. Both the inner bark and surface of the sapwood are grooved by the adult female, and eggs are packed tightly in niches along each side of the groove.

Associated with every egg gallery is a yellowish-brown stain which spreads rapidly in a vertical direction, reaching its greatest extent and development where the gallery is oldest. This is clearly illustrated by the drawing, Fig. 1, Plate II. The stain is caused by a fungus introduced by the fir engraver beetle, and probably accounts in large measure for the successful establishment of broods.

Life History.

1. Description of adult. The fir engraver beetle is a small, shining, black insect, about 3/16 inch long, which crawls by a jerking movement of its body. It is easily distinguished from other bark beetles by the concave, "cut off" appearance of the abdomen, with the hard wing covers extending slightly beyond it (see Plate II, Fig. 2C).

The adults are found only during the summer months, from about May 25 to September 1, when they emerge from broods in trees which were attacked the previous season. They are most abundant between July and August, and are commonly attracted to freshly-felled white fir trees or green fir logs lying in the shade during this time.

2. Attacks and eggs. Green trees or green fir logs are attacked by beetles in flight throughout the summer, corresponding to the flight period. The earliest record of attack taken in 1930 was on June 24, though it is probable that attacks were made before this time, since adult beetles were found on May 28. The heaviest attack occurs during July and August, corresponding to the heaviest flight period. As already explained, the attacks are shown on the outer surface of the bark by small round holes, the inner bark surface and outer sapwood surface being grooved horizontally to produce the egg gallery. At the point where the entrance hole reaches the sapwood an enlarged "nuptial" chamber is hollowed out in the inner bark, and often grooves the sapwood. From this point the egg gallery is constructed to right and left, leaving the nuptial chamber and entrance hole near the middle of and slightly below each gallery. Egg-gallery construction is done entirely by the female, while the male stays in the nuptial chamber or in the entrance hole. Eggs are packed tightly in niches along each side of the gallery, varying in number from 25 to 45 to the inch. From 10 to 14 days are required for the eggs to incubate, and from 5 to 7 weeks are required to complete an egg gallery. Eggs laid during this time hatch into white grubs which are of many ages. When egg laying is complete the female backs down into the entrance hole, where she dies, thus plugging the hole with her dead body.

3. Larvae. The larval or grub stage requires the longest period to complete its development, which is most rapid during the summer months. Cold autumn and winter temperatures force the broods to hibernate in all stages of larval development, from very young to mature larvae. Warm spring temperatures cause further development to take place, and by the first to middle of May the first pupae are found.

The larvae work out vertically from the egg gallery by feeding in individual channels that groove both the inner bark and surface of the sapwood to completely destroy the cambium. Frass material is packed tightly in each channel behind the feeding larva. When the larva is mature it bores a short distance into the bark if the bark is thick, or remains next to the sapwood if it is thin, where a small pupation chamber is hollowed out. Often in very thin bark the mature larvae bore into the sapwood a short distance to pupate.

4.Pupae. The pupal or resting stage lasts from 10 to 14 days, when the adult beetles are formed. Pupae first appear in May, and are commonly found during June, July and August.

5. Discussion. In general, the entire time required for the development of the fir engraver beetle is one year, with the time for each stage as given. Very frequently, on account of poor nourishment or cold summer temperatures the larvae are very much slower to develop, and in such cases they hibernate a second winter, the adults of such broods coming out two years after the eggs are laid. This often happens in the red fir belt, where summer temperatures are quite low.

6. Parasites and predators. The broods of the fir engraver beetle are kept in check to a considerable degree by several species of insects which are either parasitic or predacious. No attempt was made to determine to what extent the broods were kept in check by any one species of parasite or predator, but a few of them were found to be quite common. According to the frequency and number, the following insects are cited as most important:

| | Order | Family | Genus | Species | | Habit |
|---|---|---|---|---|---|---|
| 1. | Hymenoptera | Braconidae | Coeloides | brunneri | | Parasite |
| 2. | Coleoptera | Ostomidae | Temnochila | virescens | var.chlorodia | Predator |
| 3. | " | Cleridae | Enoclerus | lecontei | | " |
| 4. | " | " | Enoclerus | sphegeus | | " |
| 5. | " | " | Cecidostiba | sp. | | Parasite |

## Other Insects in White Fir

After a tree has been severely weakened or overcome by the fir engraver beetle, many species of insects are attracted to it and hasten to complete its destruction. A few of the more important species are discussed in brief. Further information will be necessary to determine their life histories and habits. In order of their importance these insects are as follows:

1. The Sierra fir borer, Tetropium abietis Fall. The adult is a medium-sized dark-brown cerambycid, about 5/8 inch long, which attacks the thick-bark portions of the lower third of the trunk after the tree has been severely weakened or overcome in the upper portion by the fir engraver beetle. These insects may be seen in flight during June, July and August, though there are never very many of them at a given time. Attacks are usually confined to the older mature trees in which the bark is quite thick, such as in Types IIB and III. The larvae work between bark and sapwood, grooving wide channels, and frequently develop to maturity before the tree has been killed. The life cycle is probably about the same as that of the fir engraver beetle.

2. The white pine scolytid, Scolytus praeceps Lec. The adult looks very similar to the fir engraver beetle, but is much smaller, being less than 1/8 inch long. The work of this species is confined to the thin bark of the top and lateral branches under 4 inches in diameter, where the inner bark and surface of the sapwood are grooved to produce egg galleries which are smaller in diameter and shorter than those of the fir engraver beetle. In rare instances the white pine scolytid attacks and kills young trees growing under poor conditions. The life cycle is about the same as the fir engraver beetle.

3. Pityophthorus pseudotsugae is a very tiny black beetle which works in the green tops and lateral branches of weakened trees. The work is easily recognized by characteristic grooving on the sapwood and inner bark to form several egg galleries radiating from a central nuptial chamber.

4. The grand fir beetle, Pseudohylesinus grandis Sw., is a small black beetle about 3 millimetres long, covered with gray and brown scales. It works under the bark of dying white fir to produce egg galleries which groove the bark and wood horizontally, so similar to the fir engraver beetle that it is often difficult to distinguish the work of the two species. The egg galleries of the grand fir beetle, however, are smaller in diameter, shorter, and possess no nuptial chamber.

5. The black pine sawyer, Monochamus scutellatus (Say)oregonensis Lec., is a large black beetle 16 to 31 millimetres long, often with white markings on the wing covers, and with very long antennae. It attacks freshly-killed white fir in the thinner bark of the upper portion of the trunk. The larvae bore in the sapwood, producing large round holes. The borings of this species are easily recognized by large shreds piled outside the holes.

6. Ambrosia beetles. Two species work in the lower part of the trunk in dying or dead white fir to produce small round holes which penetrate to the heartwood. These are the western hemlock wood stainer, Gnathotrichus sulcatus Lec., and Wilson's wide-headed ambrosia beetle, Platypus wilsoni Sw. Both species are small brown beetles which rear their young on fungus planted by the adults in the galleries.

## Possibilities of Control

As a result of studies made on white fir insects during 1929 and 1930, the fir engraver beetle is considered to be the most important cause of initial damage, and therefore control of this species would mean control of many of the other insects of less importance. As yet no methods have been developed, but an application of methods used in the control of the western pine beetle and the mountain pine beetle will be undertaken as a preliminary step during the coming season. These methods include burning, solar heat treatment, and submerging infested logs in water. Control by chemicals, such as spraying or dusting, is at present considered impractical. Biological control, such as occurs under natural conditions, is probably more effective than any artificial method that may be employed at present, but a further knowledge of this phase is necessary to confirm it.

PLATE I

Injury to White Fir Caused by the Fir Engraver Beetle

Fig. 1. Drawing of a tree which was top-killed in 1888. A secondary leader which formed below the kill remained intact until the tree was finally overcome in 1929. The 1888 top-killing, however, resulted in a weakening and also in a retardation of growth which permitted the establishment of attacks by the engraver beetle at different intervals; but these attacks were not concentrated over sufficiently large areas of bark surface to girdle the trunk until 1929. The green areas adjoining the attacked patches healed over them and left the records of past attacks buried deeply in the wood. This tree was felled in the summer of 1930, after the foliage had turned red for its entire length. In felling, the top below the secondary leader broke out in such a way that past attacks were exposed.

Fig. 2. Section as it broke from felled tree; lines connecting with Fig. 1 indicate position of this section near top of tree. The work of the fir engraver beetle is clearly shown on the surface of annual rings during the years of attack. Characteristic egg galleries, larval channels and fungus stain are perfectly preserved.

Fig. 3. End view of same section, showing years of attack and slowing-down in growth rate after the initial attack in 1888. This attack caused a thickening of the ring for that year and a suppressed growth rate for a period of years following it. In 1892, 1898, 1903 and 1904 light attacks occurred, none of them as severe as the first one. In each case the living cambium surrounding the dead areas healed over them and left the dead scars buried in the wood. The healing callus, caused by thickening of the rings as they grew over the scar, is shown on the 1904 ring. Growth rate increased after 1904 for a period of years, and this tree was not attacked again until 1928, when it was weakened to such an extent that a 1929 attack killed it.

The stain fungus associated with beetle attacks darkens the wood of the annual ring, and in the cross-section may be confused with fire scars.

Drawings by W.D. Edmonston

PLATE I

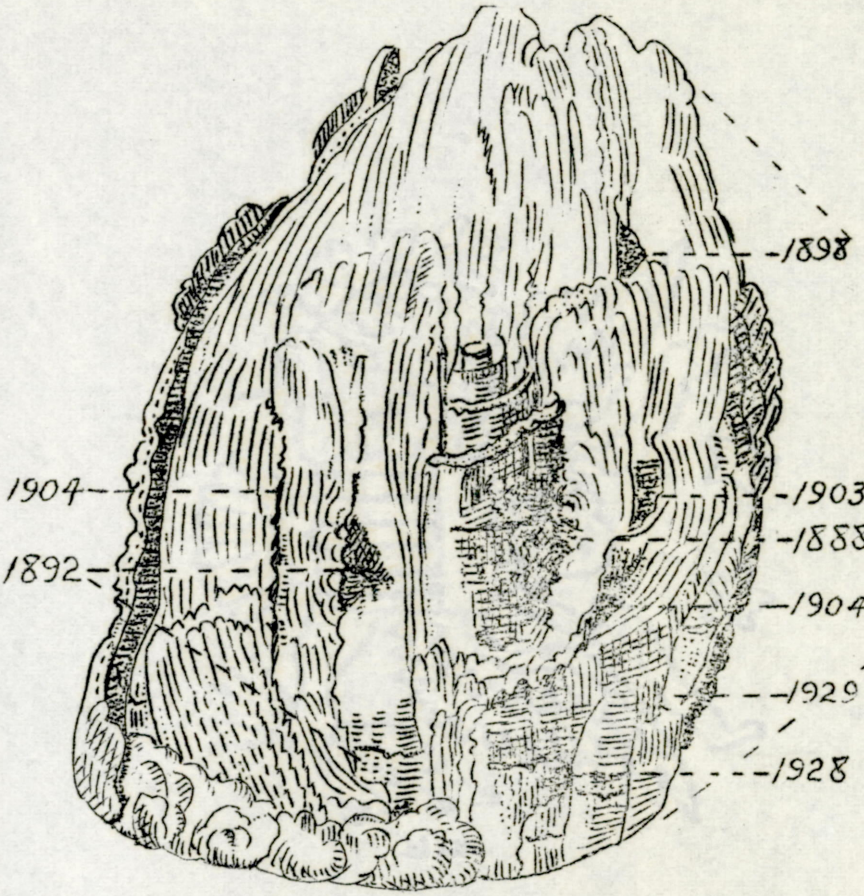


Fig. 2

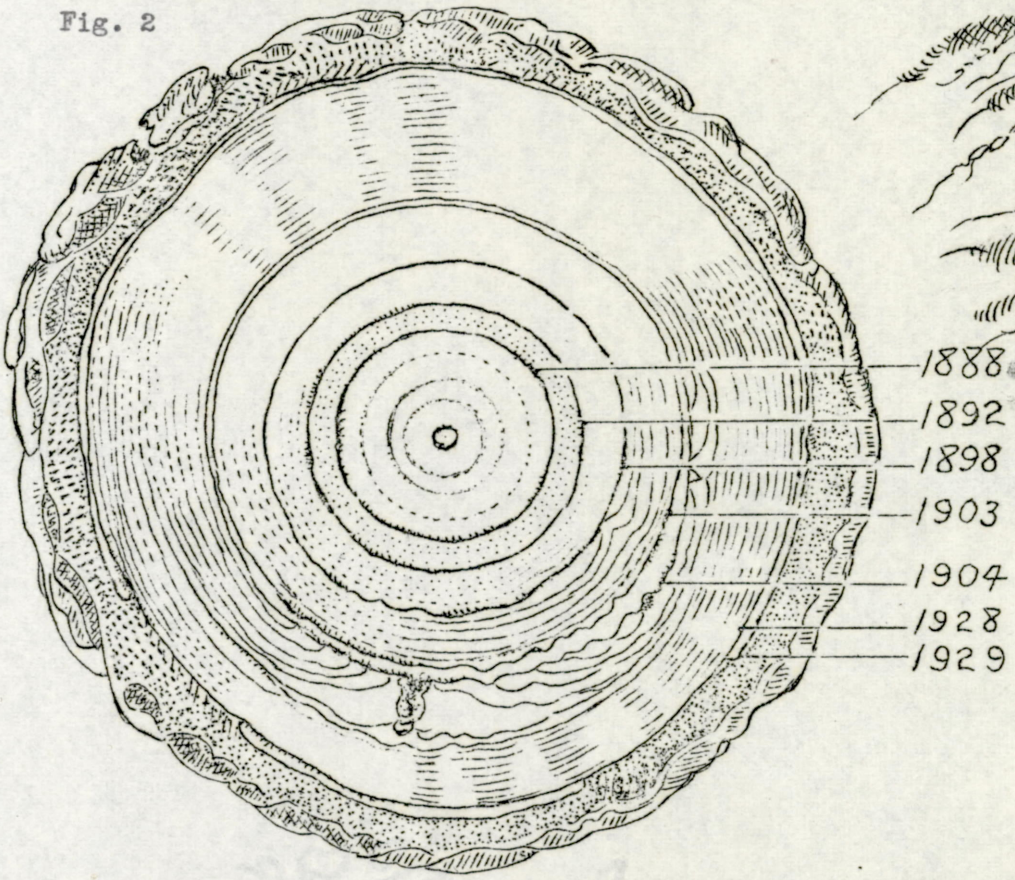


Fig. 3

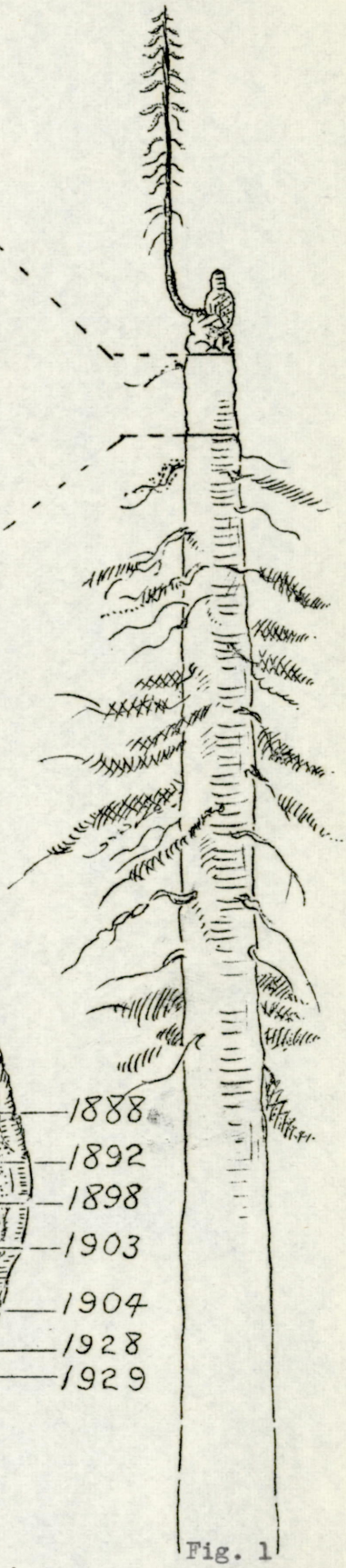

Fig. 1

PLATE II

Life History Stages and Work of the Fir Engraver Beetle, *Scolytus ventralis* Lec.

Fig. 1. Natural-size drawing of egg gallery, showing larval channels and stain development as they occur on the inner bark surface, next to the cambium, of a recently-attacked green white fir. This attack is approximately four weeks old. The large in-curved notch in the center of the egg gallery is the nuptial chamber, and leading into it is the entrance hole from the outside. Egg-gallery construction began at the left of the nuptial chamber, where the first eggs were laid. The larvae that developed bored out in channels, the oldest larvae indicated by the longest channels. After the adult female had bored for approximately two inches to the left, she turned back to the nuptial chamber and there started a gallery to the right of it. Egg laying and gallery construction were still in progress when the bark was removed, exposing this attack.

The fungus stain development has reached its greatest spread, corresponding to the oldest part of the egg gallery. It stains the cambium, sapwood and inner bark yellowish-brown in the earlier stages of growth and dark-brown in later development. The differences are indicated by the drawing. The spread of this fungus is always with the grain of the wood, this being also the direction in which the larvae feed.

Fig. 2. Enlarged drawings of different stages of the fir engraver beetle, *Scolytus ventralis* Lec.

a. Larva
b. Pupa
c. Adult

Drawings by W.D. Edmonston

PLATE II

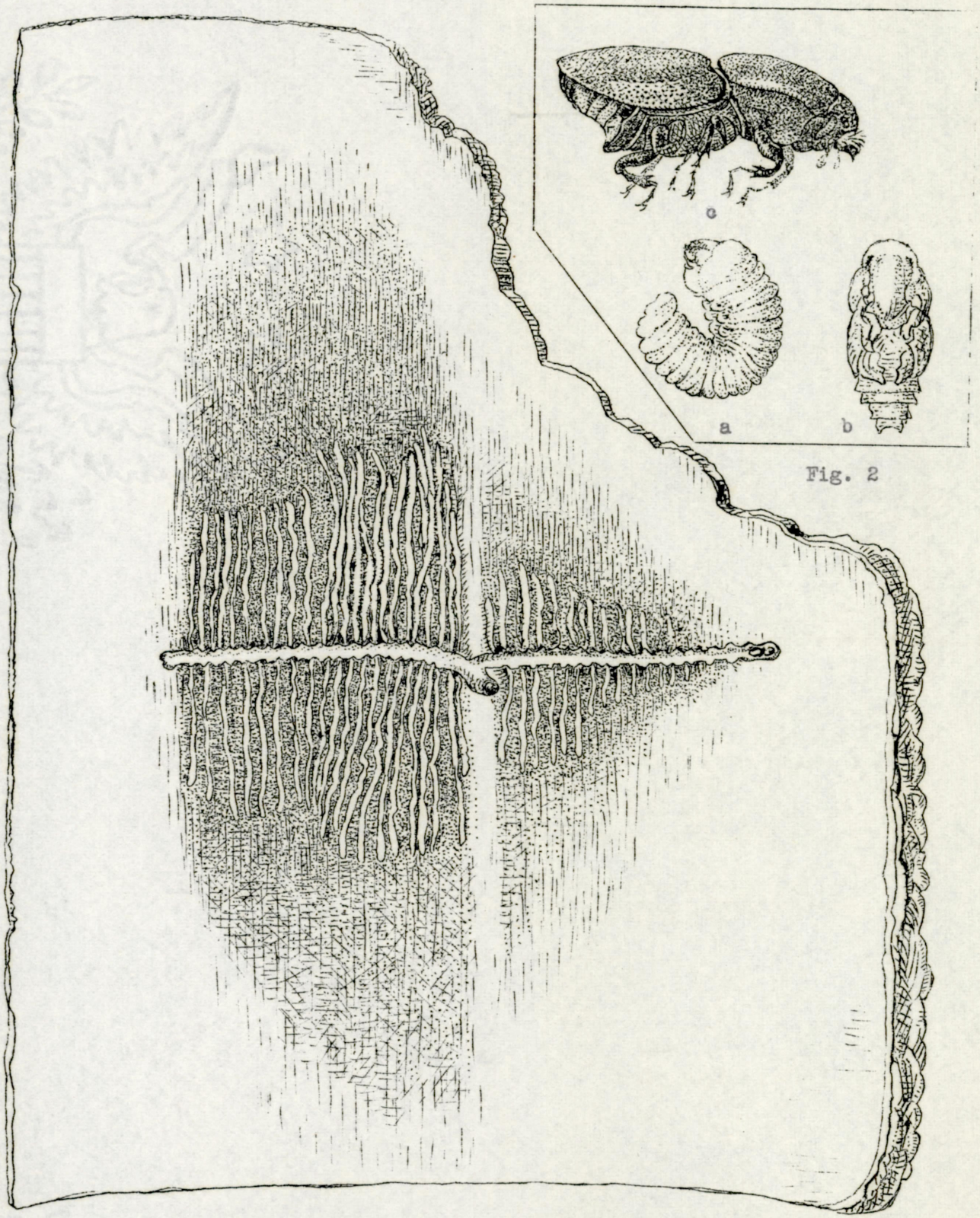


Fig. 2

Fig. 1

SEASONAL DEVELOPMENT OF *SCOLYTUS VENTRALIS* LEC. BROODS REPRESENTED BY EGG GALLERIES AND LARVAL MINES ON SURFACE OF SAPWOOD

This series is composed of separate galleries exposed by removing bark at definite intervals after parent beetles entered bark. Each photograph represents a separate egg gallery resulting from attacks which occurred on a trap log at Pine Crest, California, July 5 to July 9, 1931. These were uncovered one week apart from July 9 to Aug. 13. Illustrations two-thirds natural size.

*The development period from eggs to mature larvae was 42 days in 1931, due to unusually warm seasonal temperatures. Pupation and emergence then occurred before fall. From 75 to 90 days is the usual time required for larvae to mature in the fir belt, and cold temperatures at the end of this time cause the larvae to overwinter.*

FIG. 1 — *Attack from 4 to 6 days old. Entrance and nuptial chamber at left and egg gallery with egg niches extended to right. One male and one female per attack; male remains near entrance while the female constructs the egg gallery. (Adult beetles were lost when bark was removed.)*

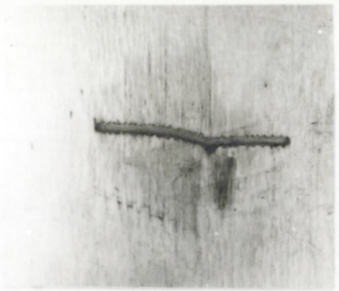

FIG. 2 — *Egg gallery about 10 days after attack. In this attack gallery was first constructed to left then to right of nuptial chamber. No choice is apparent in direction of gallery other than horizontal. Beginning of fungus stain development shown as darkened areas on each side of egg gallery.*

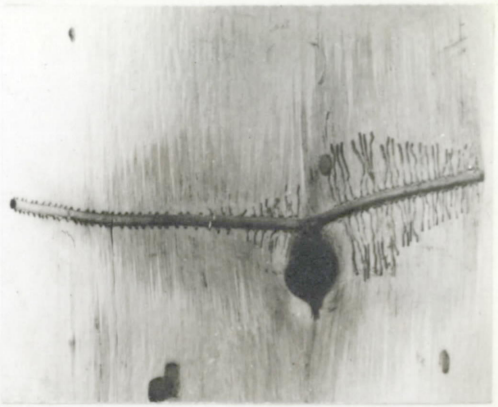

FIG. 3 — *Twenty days after attack; showing incubation of eggs and beginning of larval mines. Oldest part of egg gallery shown by longest larval mines and widest stain.*

FIG. 4 — *Thirty days after attack. Nearly all eggs have incubated except those last deposited near extreme ends of egg gallery. (Clouded area in upper part of photo due to bruising of sapwood in removing bark.) Arrow points to young larval mine of Sierra Fir Borer which followed the Fir Engraver beetle in attack on log.*

FIG. 5 — *Forty days after attack; with oldest larvae one-half to two-thirds grown. A few larval mines of the Sierra Fir Borer mixed with Fir Engraver beetle larval mines. Egg laying complete.*

FIG. 6 — *Forty-seven days after attack. Oldest larvae mature; some having already constructed pupal cells (see arrows). (Circular black area below entrance is small pin-knot; a similar knot is shown in FIG. 3.)*